Cornell University
Laboratory for Elementary-Particle Physics

# Experimentally Observed Defects in Niobium SCRF Cavities Tested at Cornell

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# Acknowledgements


- Cornell SRF Group
  - Especially: Don Hartill, Hasan Padamsee, and Eric Smith

- FNAL: Mark Champion, Camille Ginsburg, Genfa Wu

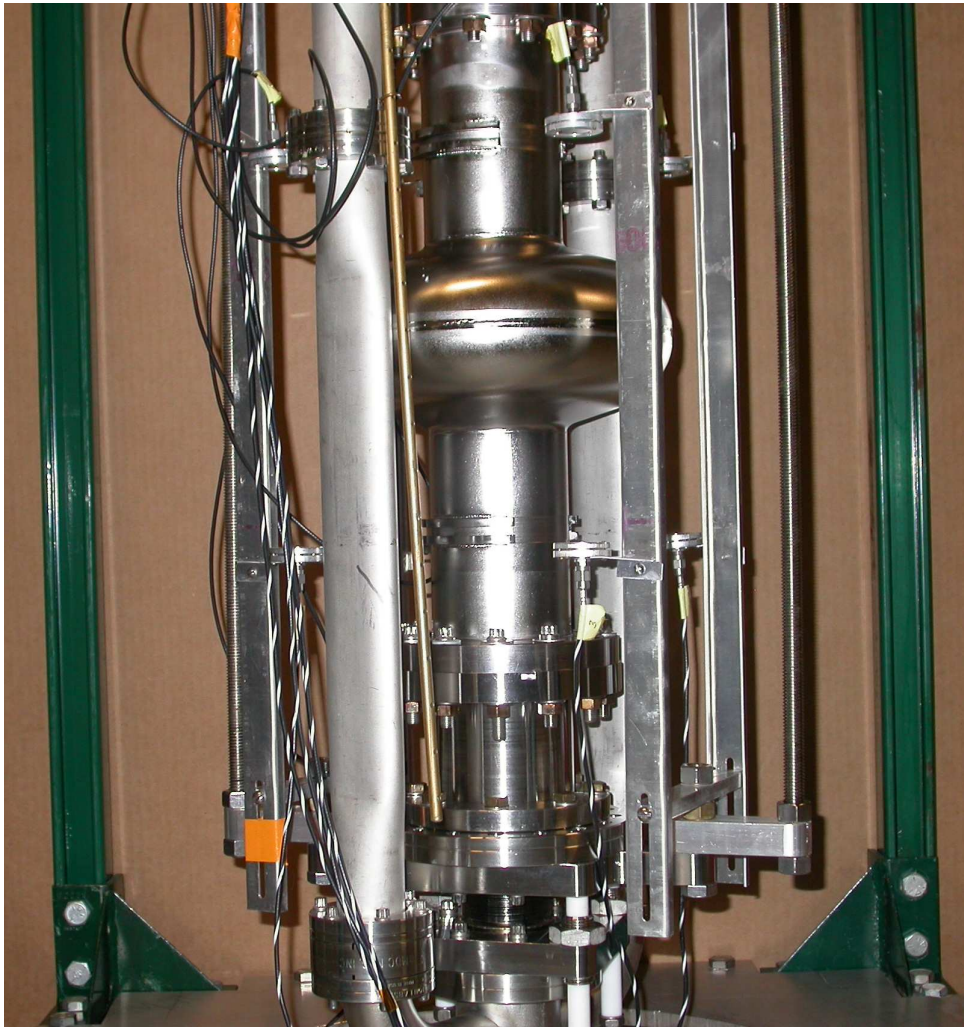
# Talk Overview

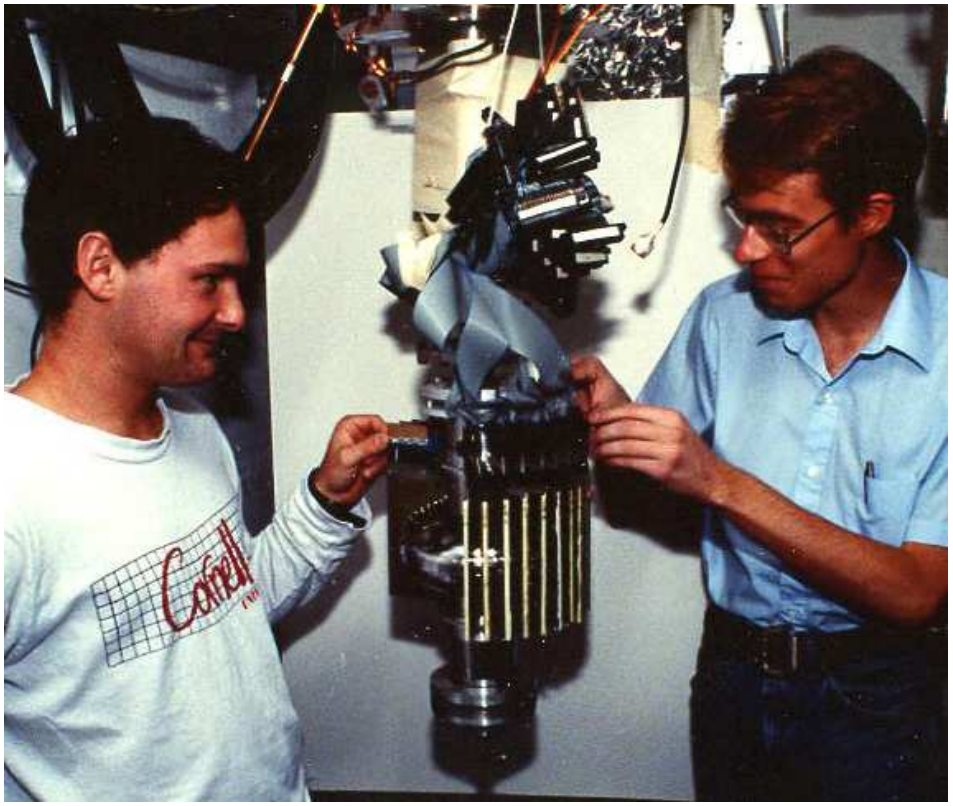
- Summary of cavities tested.
- Defect Location.
- Defects in SCRF cavities fabricated from niobium sheet.
- Where is this going & a brief summary of major points.

# Defect Location

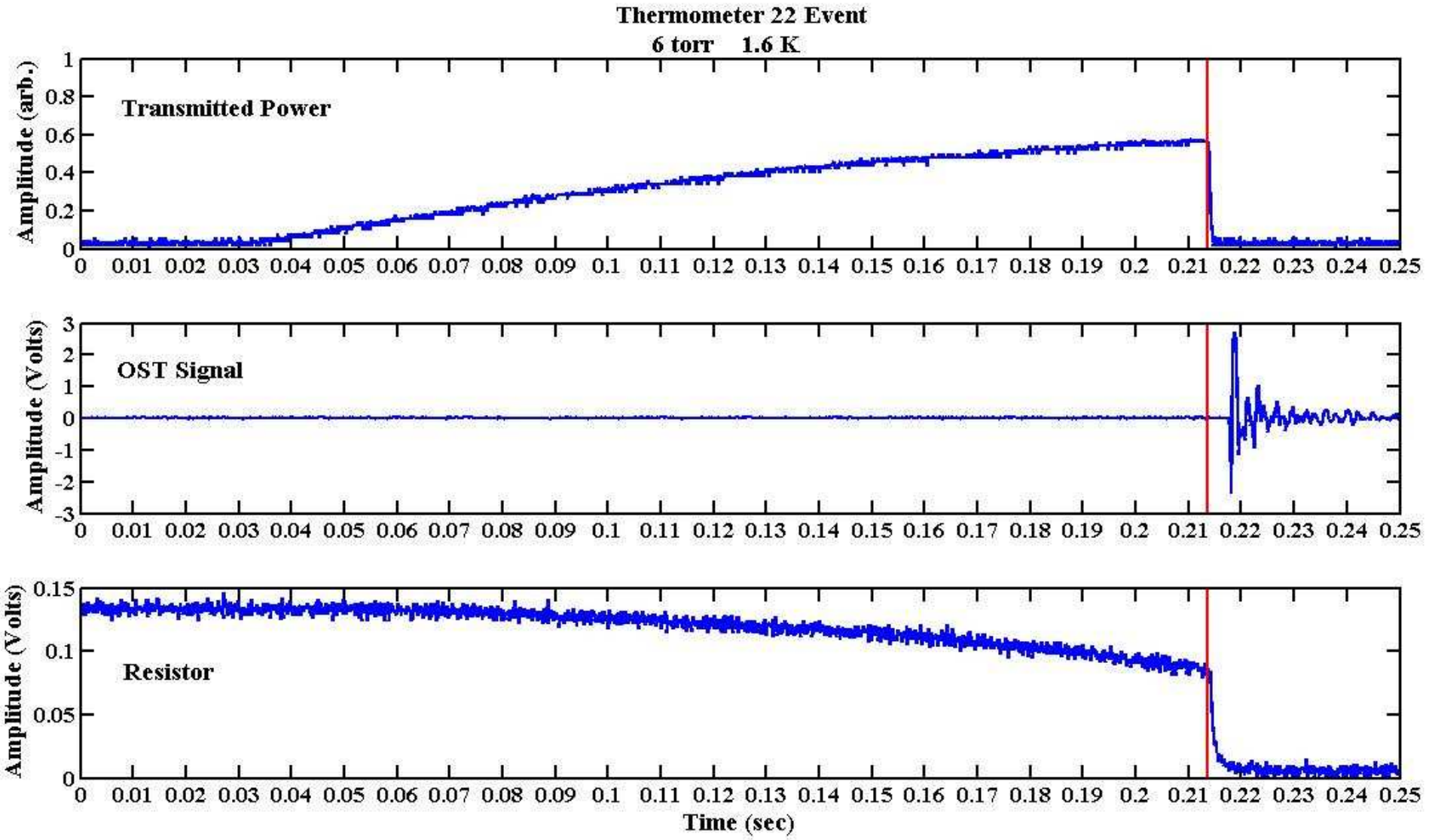
- Simple defect localization schemes can be implemented by exploiting the properties of superfluid He, e.g. second sound waves.
- When a cavity quenches, typically several joules of thermal energy are transferred to the helium bath in a few microsecond.
- If the cavity is operated at $T < 2.17K$, the helium bath is a superfluid and a second sound wave propagates away from the heated region of the cavity.
- By locating several transducers in the helium bath around the cavity, the second sound wave front can be observed. The time of arrival of the second sound wave at a given transducer is determined by the time of flight from the heated region, which is centered on the defect causing quench.
- Measuring the time of flight to 3 or more uniquely located transducers, unambiguously determines the defect location.

# Cavity Defects





# Defect Location



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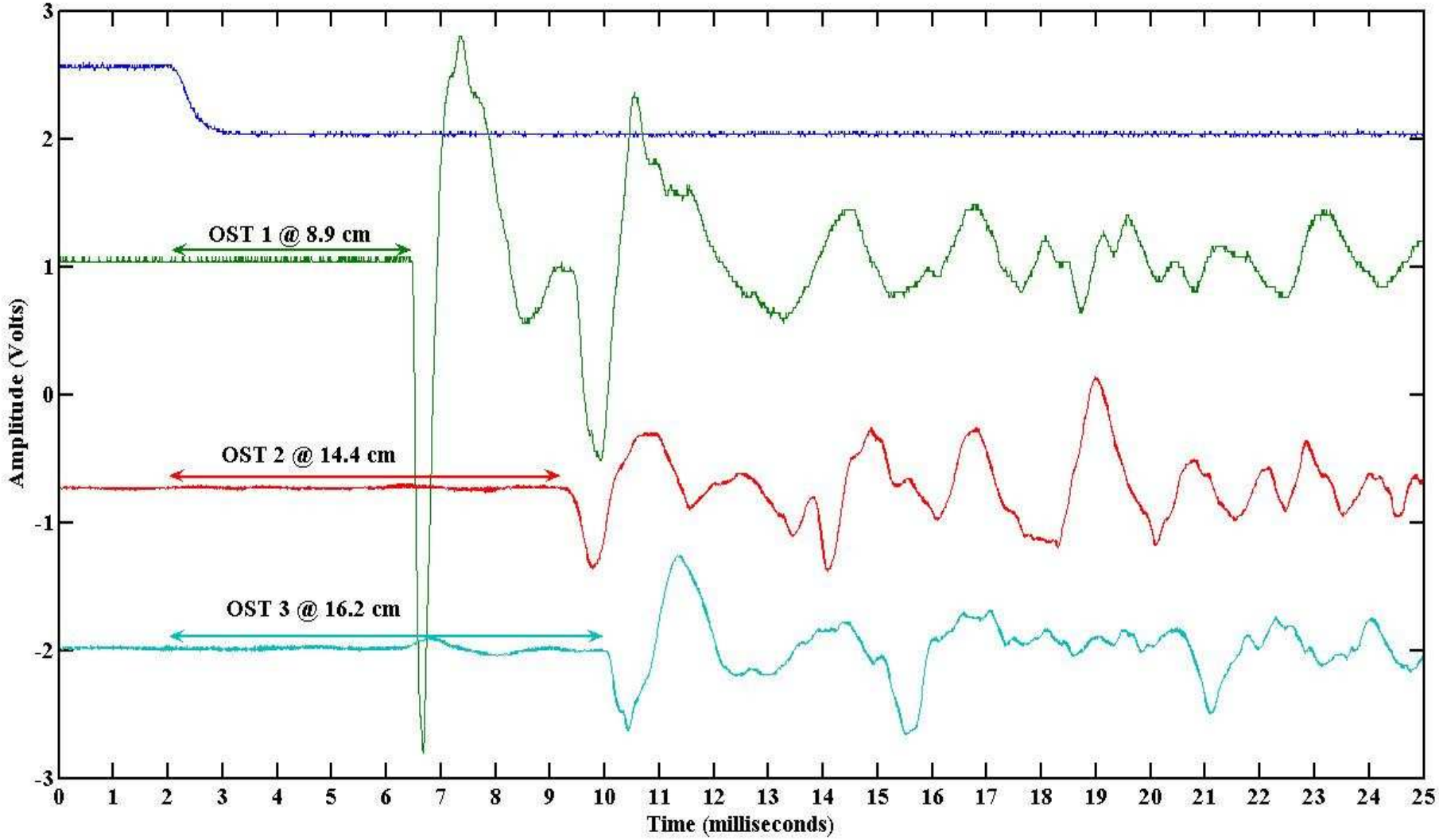

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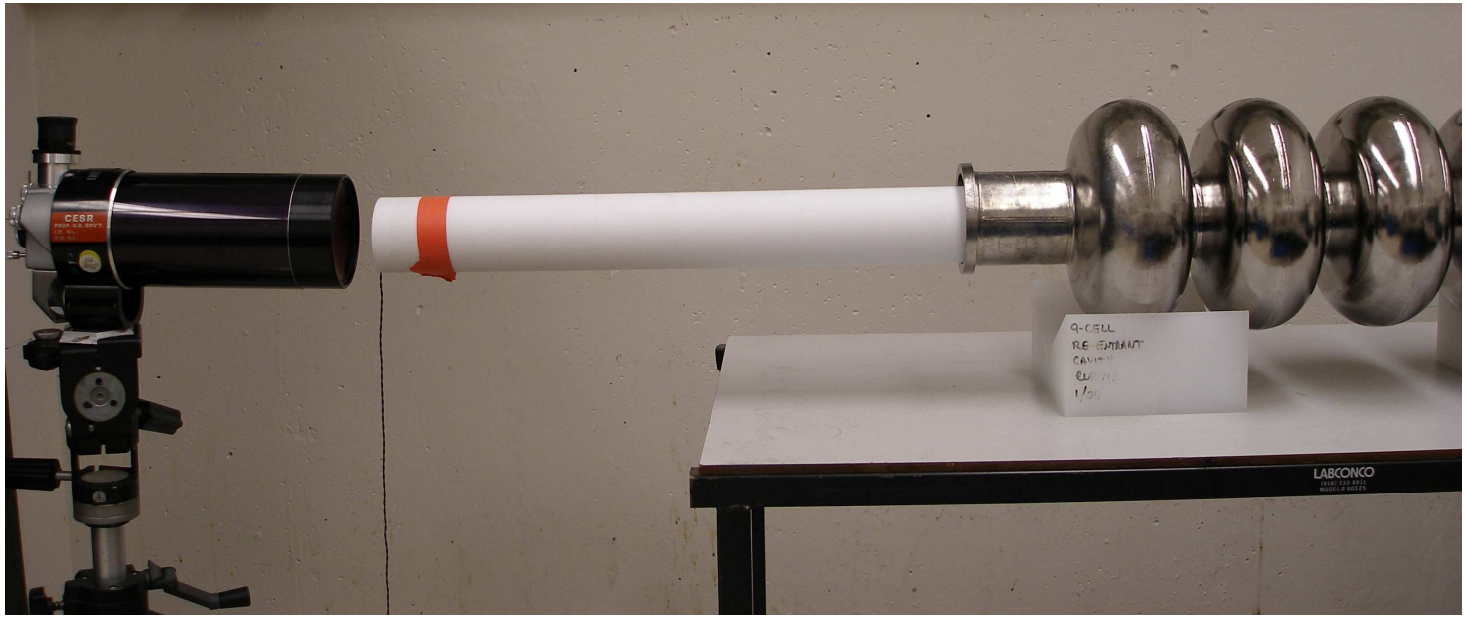
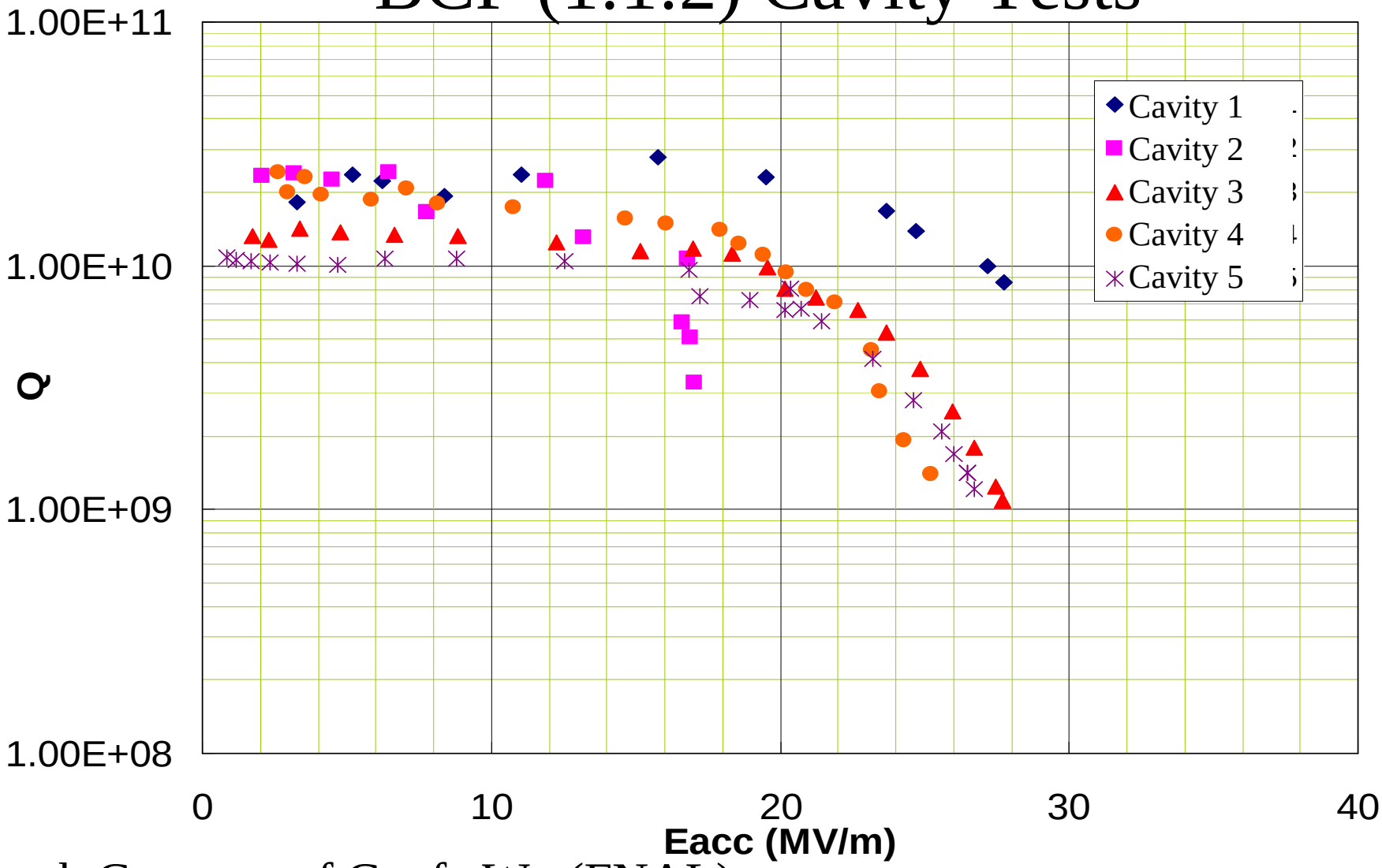


# Cavity Defects

- In the past 1.5 years we have tested 15 distinct cavities from three different fabricators.
  - 12 TESLA style single cell cavities.
  - 1 re-entrant single cell cavity
  - 1 re-entrant 9-cell cavity
  - 1 9-cell ILC type cavity
- Test Results:

# Cavity Testing

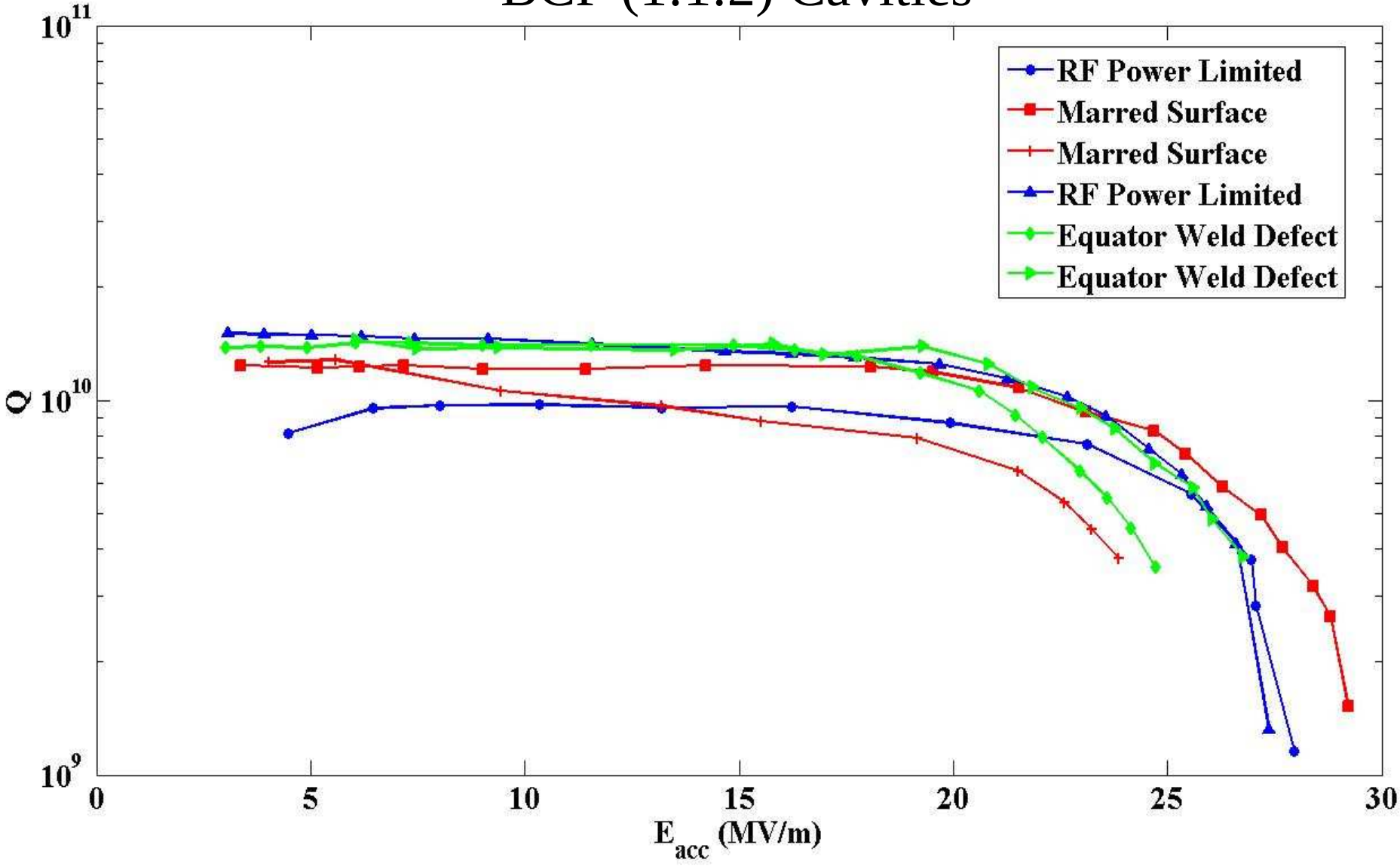
## BCP (1:1:2) Cavity Tests




Graph Courtesy of Genfa Wu (FNAL)

# Cavity Testing

## BCP (1:1:2) Cavities



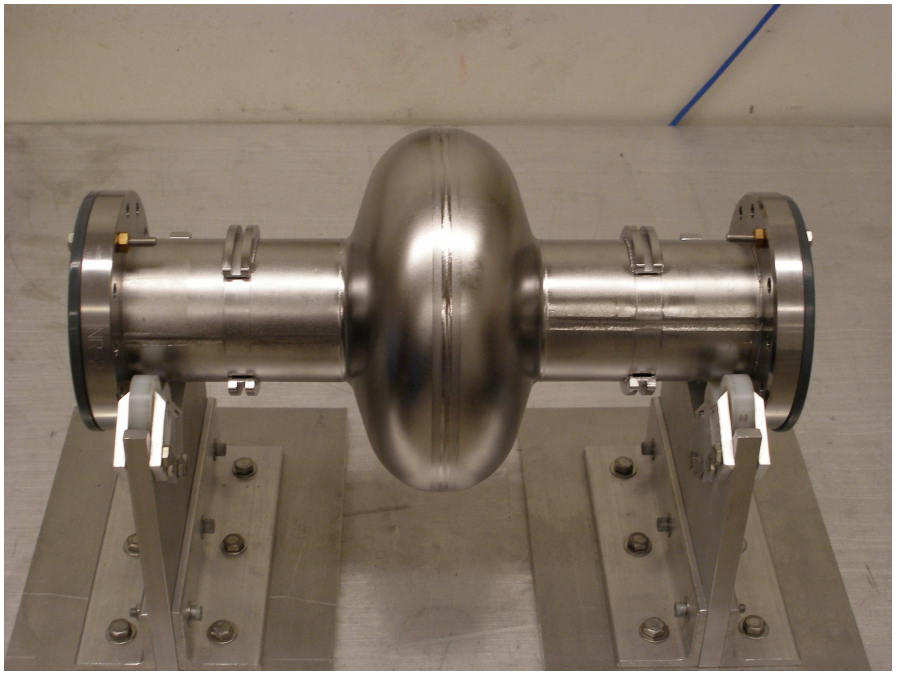
# Cavity Defects

- Defects located (everywhere):
  - On the inner surface of the cavity but not on the iris or the equator Electron Beam Weld (EBW).
  - On the equator EBW.
  - On the Iris (field emitters)
  - No obvious optically observable defect at quench site.

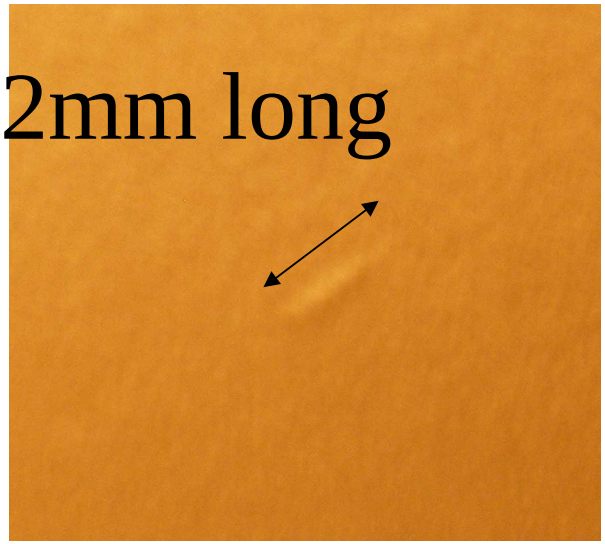
- First, defects not on the iris or the equator...

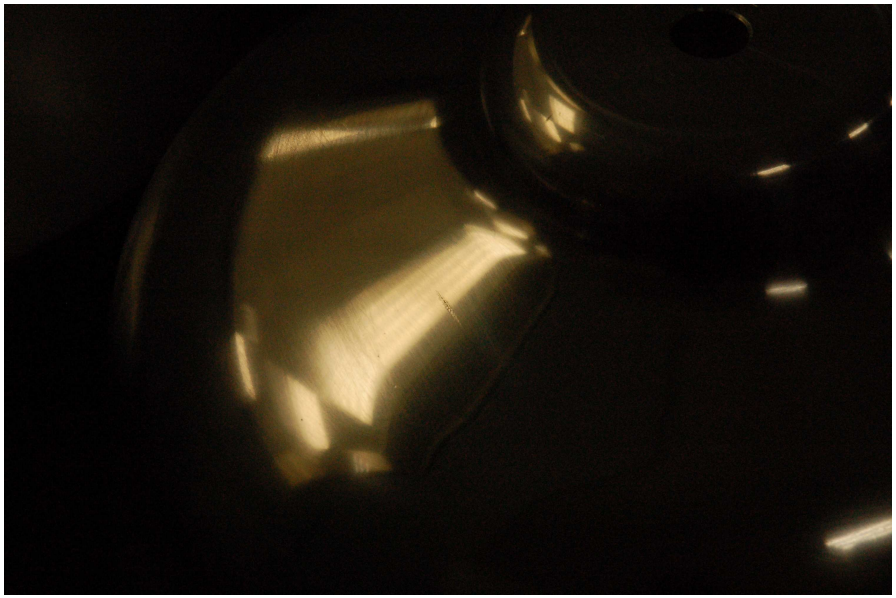
# Surface Defects

- Two cavities tested last year quenched but the defect was not located on the equator EBW or the iris.



# Surface Defects



Right-hand picture courtesy of Charles Reece (JLAB)

and Genfa Wu (FNAL)

# Surface Defects

- An additional 100 μm BCP etch of these 2 cavities "fixed" this defect.

- Equator EBW defects were then encountered which limited the maximum achievable surface fields.

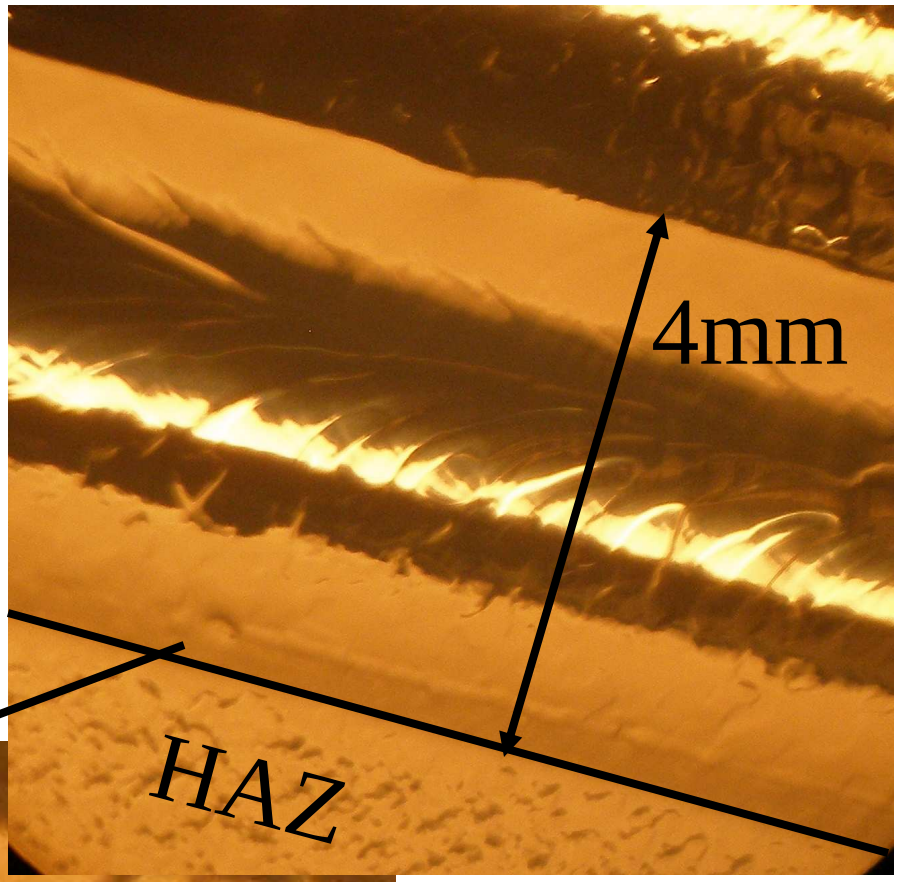
# Equator EBW Defects

- Weld defects encountered.
  - Bumps/Pits
  - Deformed Welds
  - Trenches
  - Nothing visible optically at all…

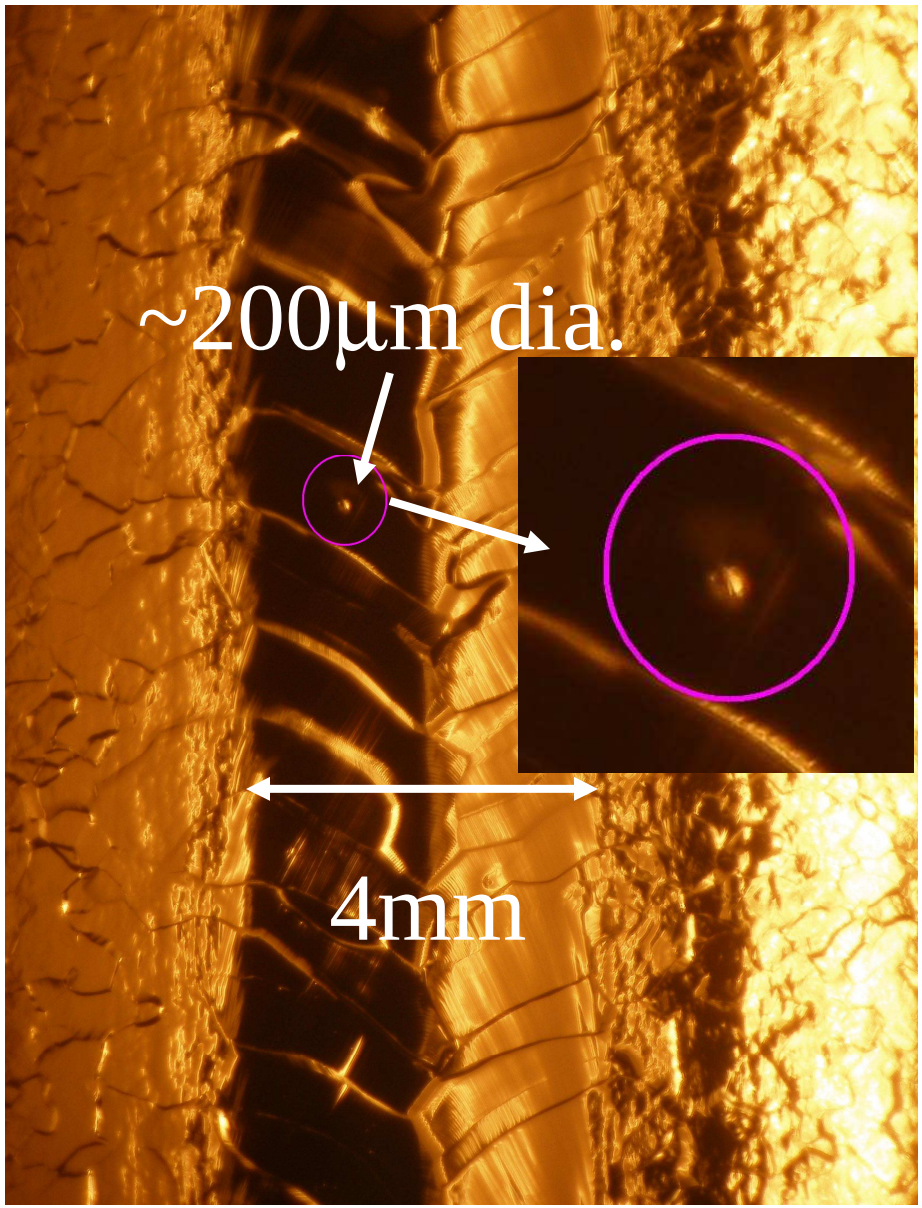
- First, a look at bumps/pits (~38% of defects found).

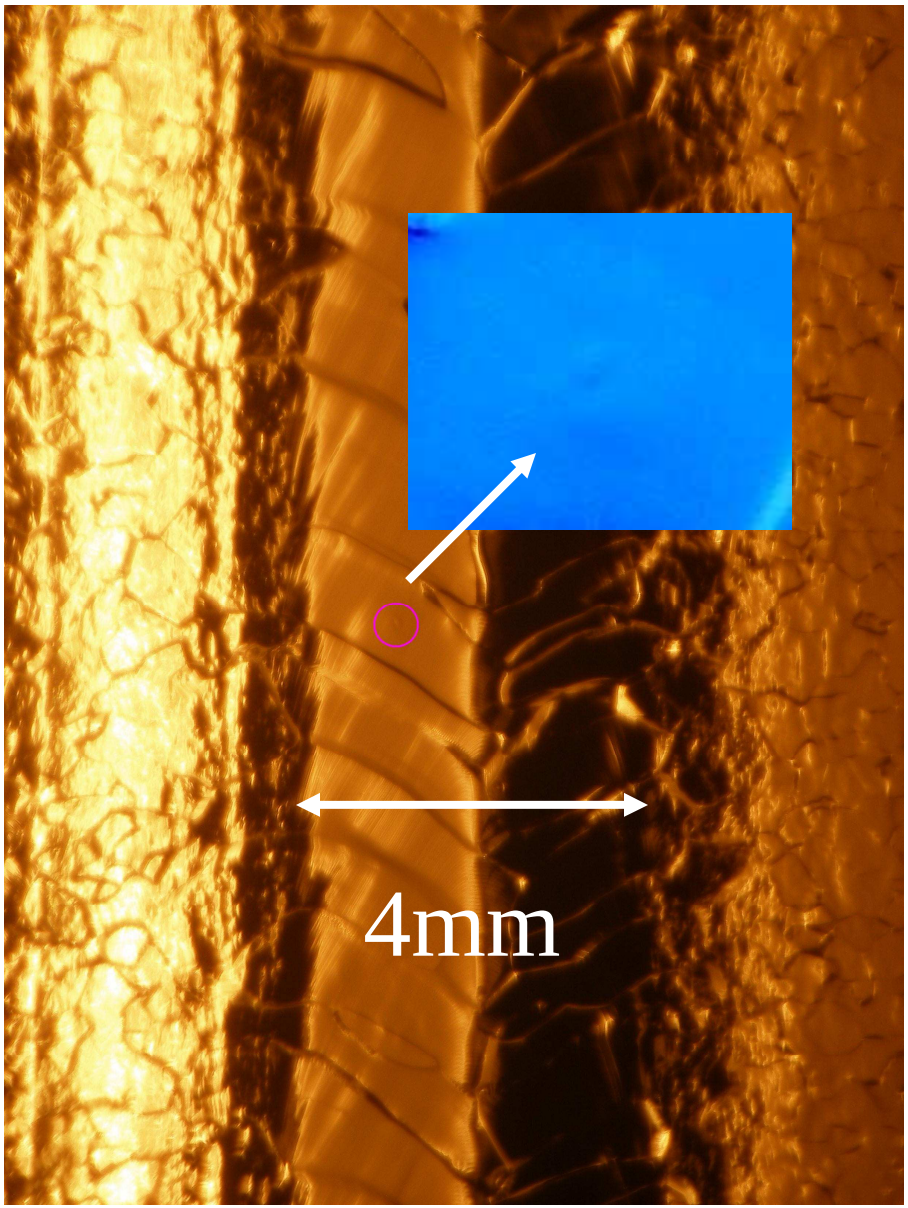
# Equator EBW Defects

- Pit with protruding line…
- Origins of feature unknown.
- Removed with tumbling.
- Further testing in the next two months.



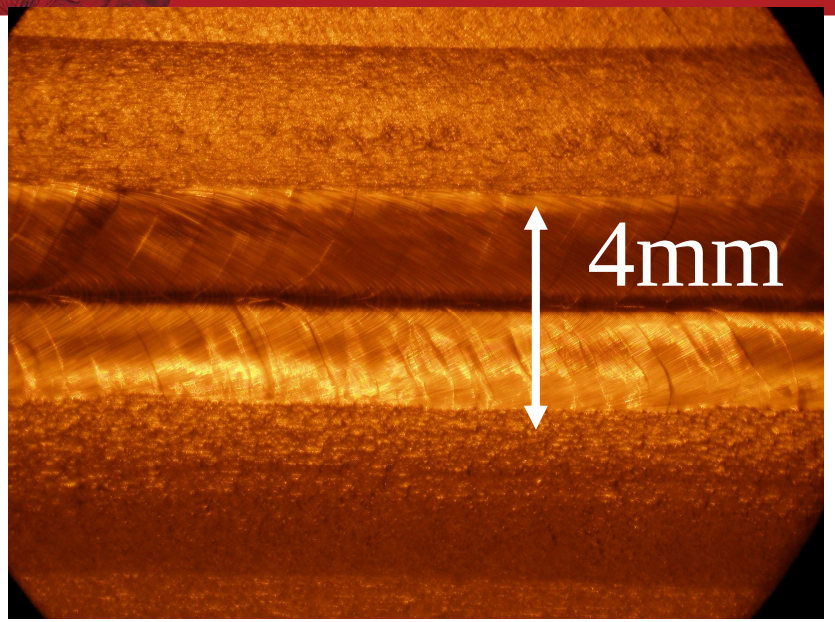

# Equator EBW Defects

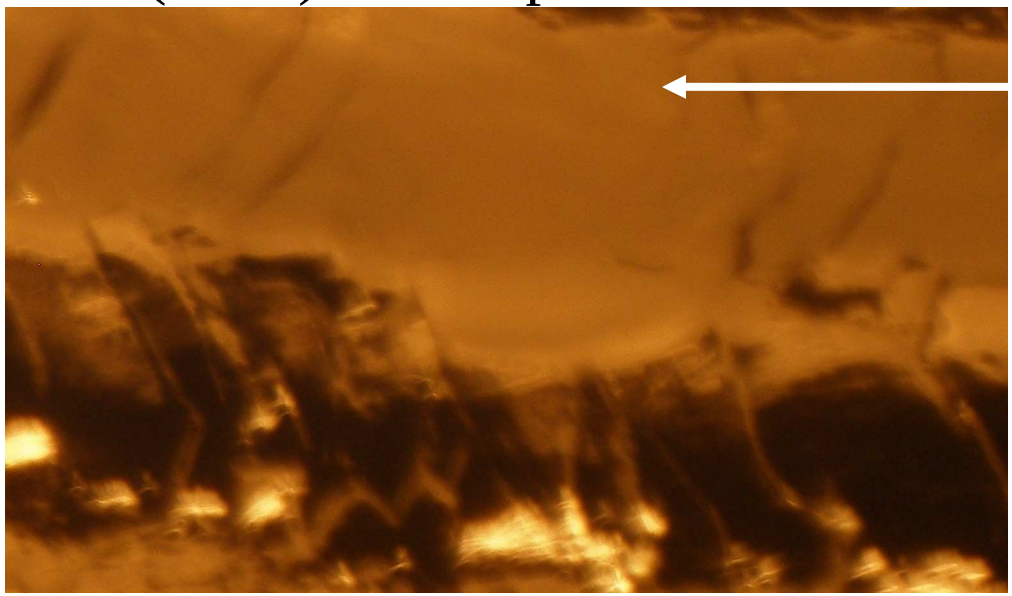


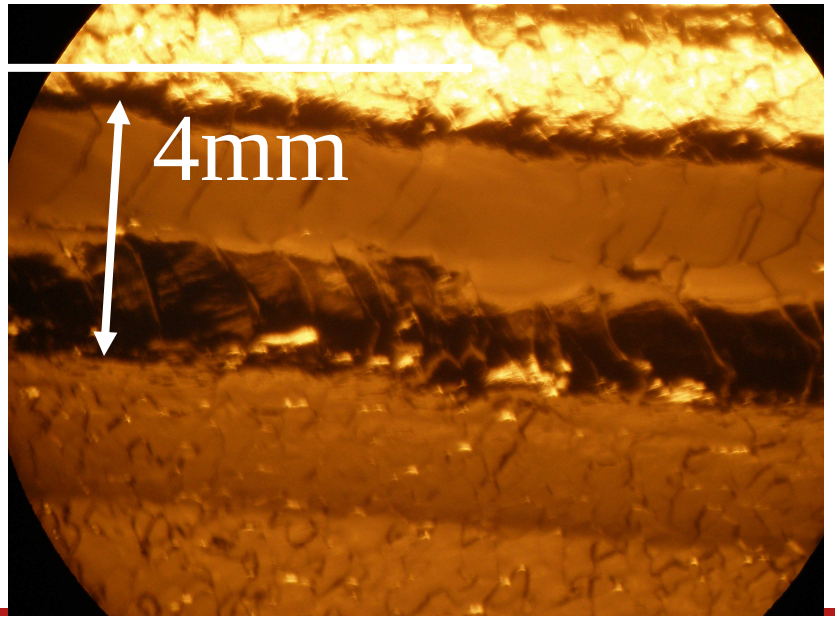



# Equator EBW Defects

- Deformed welds (25%)
- Cause unknown?
- The outside weld looks perfect.
- The entire circumference of the inside weld before BCP (1:1:2) looked perfect.

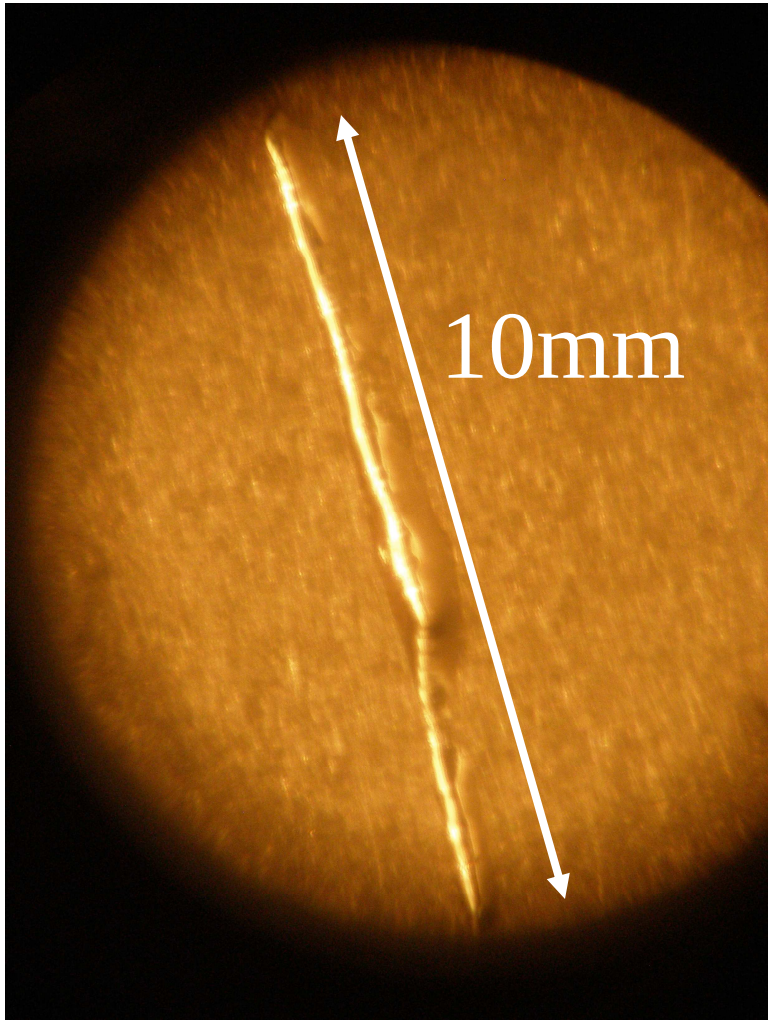




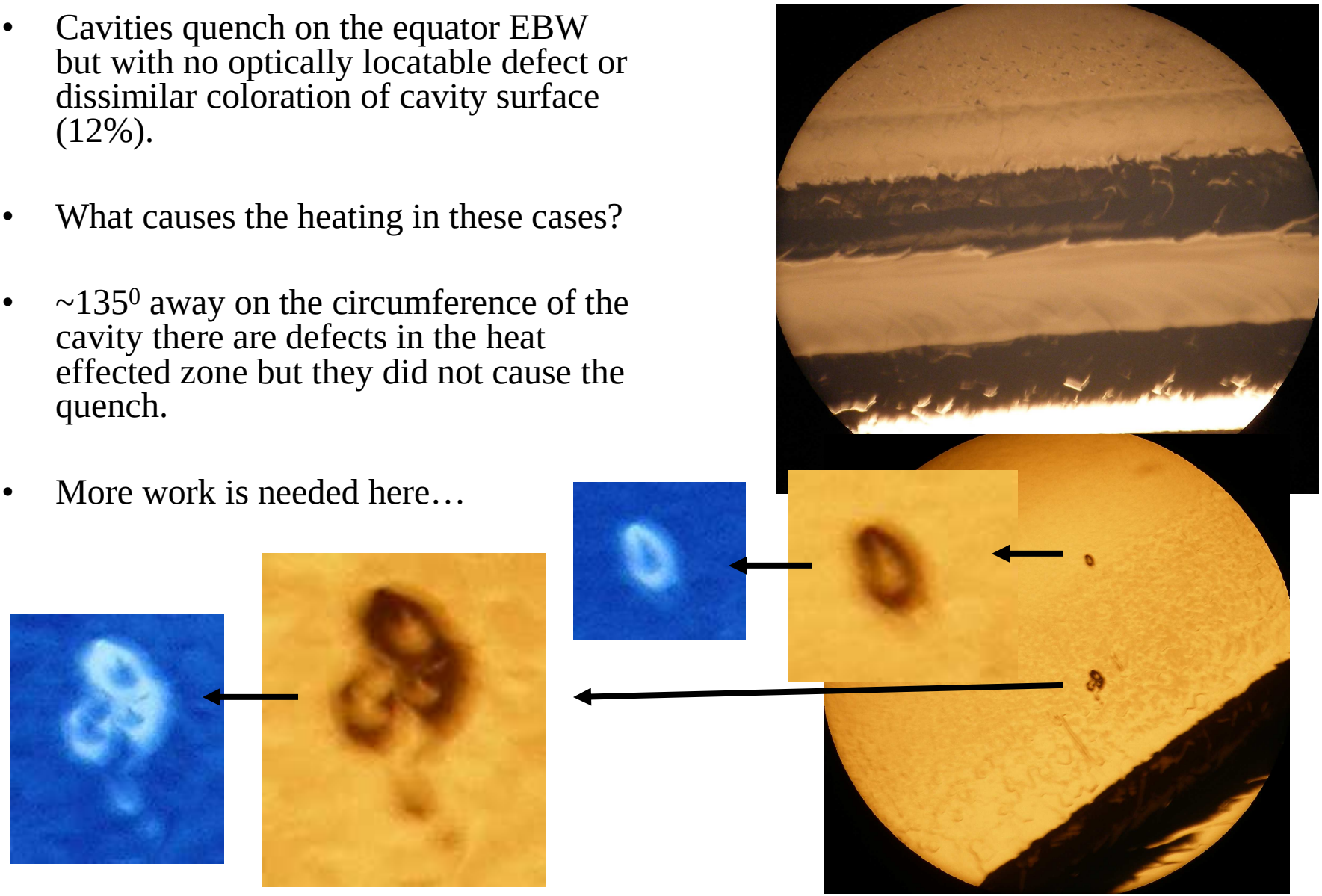
# Equator EBW Defects

- Trenches in equator EBW (25%).
- Due to faulty EBW welding.
- Picture on right is after tumbling. Improved contrast of trench.
- This trench is located at the EBW overlap.
- EP and BCP do not remove these defects. Tumbling or local grinding required.



# Equator Weld Defects

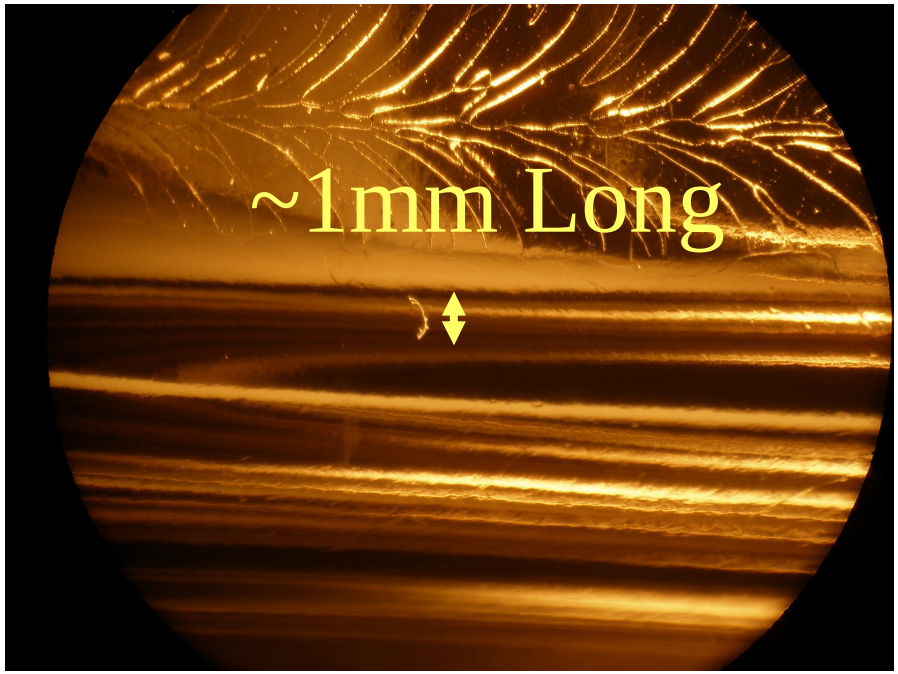
- Cavities quench on the equator EBW but with no optically locatable defect or dissimilar coloration of cavity surface (12%).
- What causes the heating in these cases?
- ~$135^0$ away on the circumference of the cavity there are defects in the heat effected zone but they did not cause the quench.
- More work is needed here…

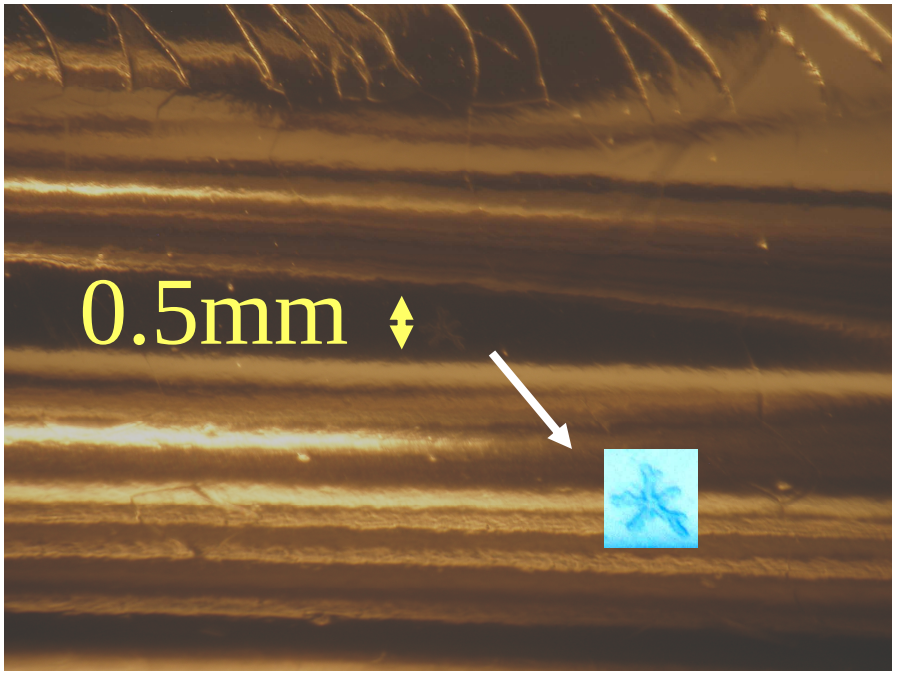


# Iris Defects

- Iris defects are located indirectly.
- Cavity heating due to field emission is detected.
- One must work their way back up to the iris to find the defects.

# Iris Defects



# Where is this going?

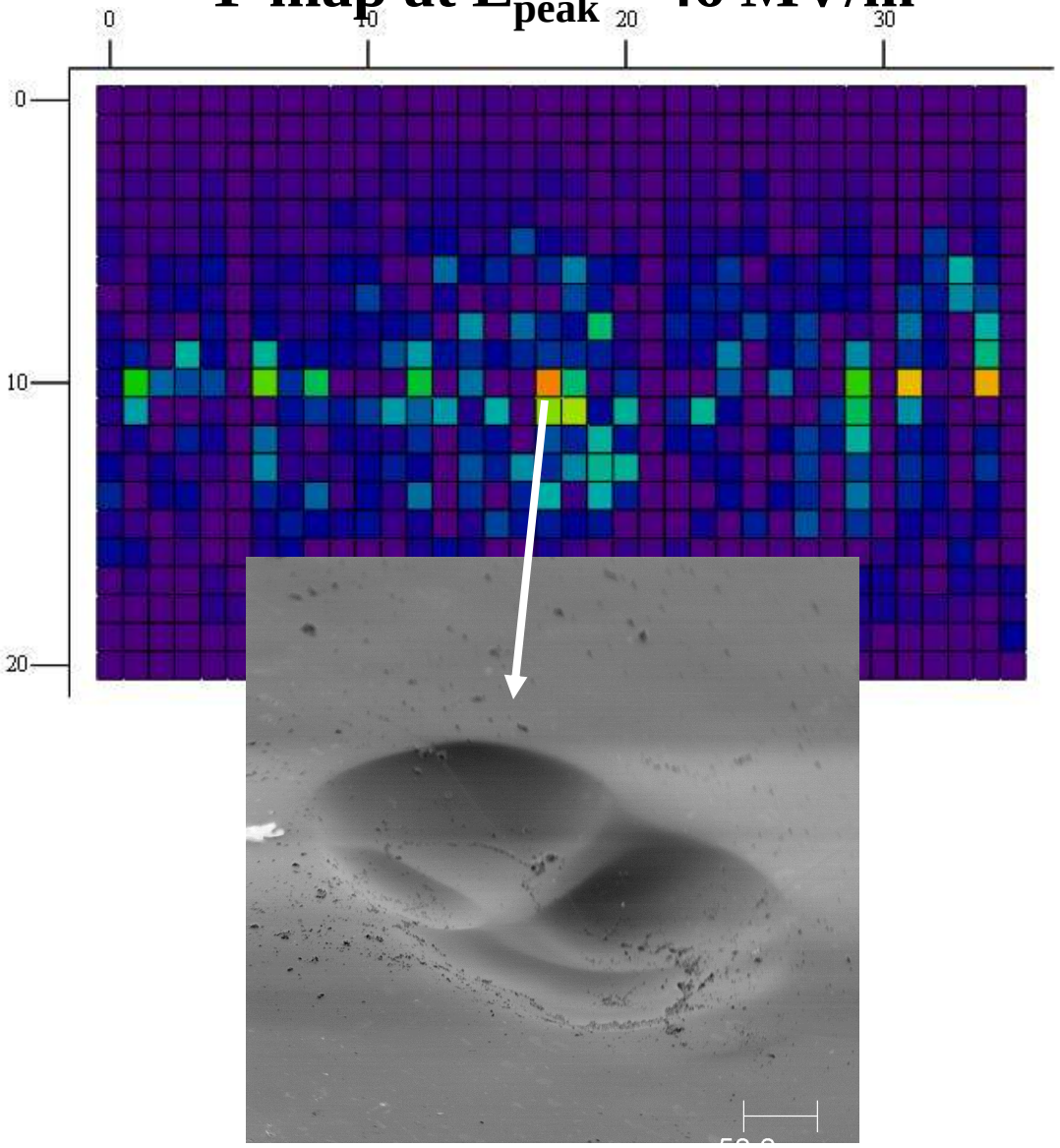
- Pictures of cavity defects have limited use.

- We need more information.
  - SEM
  - Measure any impurities.
  - Ect…

- For example…

# Cavity Defects

**T-map at $E_{peak}$ = 46 MV/m**



# Summary

- SCRF cavity quench limits the maximum achievable gradient.

- The defects can be located anywhere on the cavity surface and are due to fabrication errors, handling errors, EBW errors, and other sources which remain unknown…

- Bumps are not a problem.